JET PROPULSION LABORATORY INTEROFFICE MEMORANDUM

June 09, 2004

TO: G. Burke

FROM: S. Guduru

SUBJECT: Mars Odyssey Extended Mission Loading Study

The Resource Allocation Planning and Scheduling Office (RAPSO) performed a loading study to determine the impact of the updated Mars Odyssey (M01O) extended mission tracking requirements on the Deep Space Network (DSN) and the ability to support those requests.

Summary

Overall Mars Odyssey is expected to receive 85 to 90% of the requested time for the duration of the extended mission. There is no significant impact in 2007 and 2008. However in 2005 and 2006, there are periods (November 2005 thru April 2006) where supportable time falls below 80%. The contention during this period can be reduced with increased use of MSPA support with other MARS missions like Mars Express Orbiter (MEX) and Mars Global Surveyor (MGS). Currently, we forecast that Mars Odyssey should not have MCD-3 conflict with other users except during the period February thru June 2005 at Canberra (DSS-43), which can be avoided with careful scheduling and negotiation with Stardust (SDU).

Analysis was accomplished using the FASTER (Forecasting And Scheduling Tool for Earth-based Resources) forecasting system, the Mars 6-degree-mask view period, and the updated mission set database from the February 2004 Resource Allocation Review Board (RARB).

Requirements

Mars Odyssey extended mission requirements begin on August 24, 2004 and continue until December 31, 2008. Support from the 70-meter Subnet is preferred due to the increased downlink gain and resulting telemetry bit rate available for the mission when tracking with a 70-meter antenna. Since M01O's request for 10-hours per day on the 70-meter has already been negotiated in the RAPSO mid-range schedule almost through the end of year 2004, this study focuses on the period starting from Jan 2005 till Dec 2008. It addresses Mars Odyssey's extended mission requirements forecast on the 70-meter Subnet keeping in place the agreements to do multiple spacecraft per antenna (MSPA) support with Mars Express Orbiter (MEX) and Mars Global Surveyor (MGS) as a result of RARB negotiations and agreements. See the User Loading Profile for weekly requirements, MSPA usage, and resource distribution attached to this study.

The requirements for the extended mission are as below:

Mission Event	Dates	Requested Support
Routine Tracking	24 Aug 2004 to 31 Dec 2008	10-hours per day on 70 M
THEMIS Augmentation	01 Nov 2005 to 30 Apr 2006 01 Dec 2007 to Apr 2008	20-hours per day on 70 M
Phoenix UHF Relay support	18 May 2008 to 30 Nov 2008	Continuous (70M, 34M)

M01O requests MCD-3 usage during the following periods:

Jan 2004 to June 2005
Feb 2006 to Sept 2007
Mar 2008 to Dec 2008

Assessment

Figure 1 shows the weekly supportable percentage of requested time for the duration of the extended mission. Mars Odyssey should expect to receive on average 85 to 90% of the requested time on the 70M Subnet except when the supportable time falls below 80% in November/December of 2005 and January of 2006. A detailed analysis for this period is combined with the analysis for THEMIS augmentation support during this duration and is as discussed below.

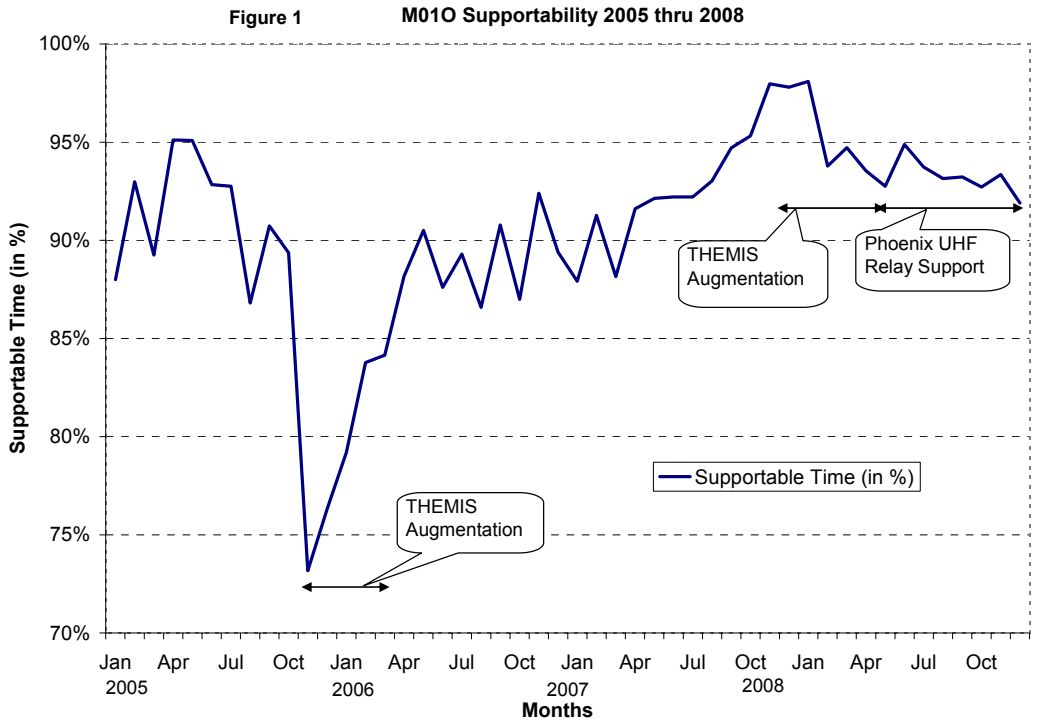
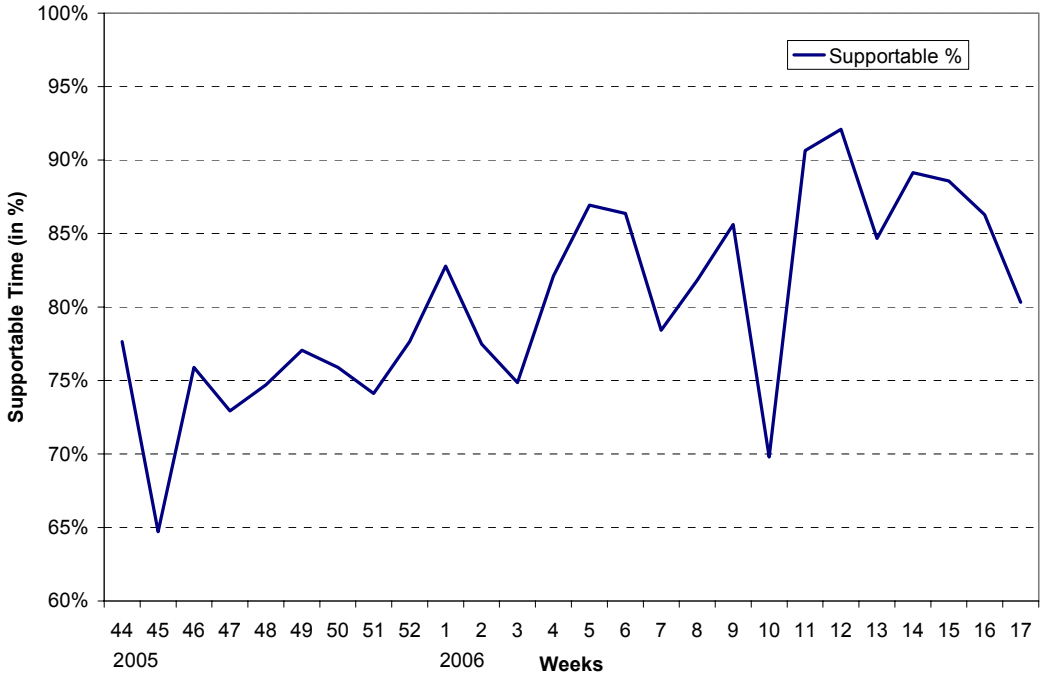


Figure 2 THEMIS Augmentation Nov 2005 - Apr 2006



THEMIS Augmentation

Figure 2 shows the weekly supportable percentage of requested time for the THEMIS augmentation period from November 2005 thru April 2006. During this period M01O is forecast to receive an average 75 to 80 % of the requested time on the 70M subnet except in weeks 45, 47 and 51 of 2005 and week 10 of 2006 where the supportable percentage falls below 75%.

In November and December 2005 (weeks 44 thru 52), DSS-43 is down for antenna controller/hydrostatic bearing maintenance causing 70-meter users to be supported at DSS-14 and DSS-63 only. Contention is primarily at DSS-14. During this period, M01O requests 20-hours per day on the 70-meter and is in contention with several other users for support on this Subnet. Cassini (CAS) requires 1 to 5 supports of 9-hour duration each for Saturn tour, European VLBI Network (EVN) requires a 5-hour support for pre calibration and two 9-hour supports simultaneously at DSS-14 and DSS-63 for the E500 J-M4 activity in week 45, Goldstone Solar System Radar (GSSR) requires 2 to 3 supports of 4-hour duration each for the asteroid 1862 Apolo observation in weeks 45 and 46 at DSS-14, it also requires two 1-hour supports each week for Mars Radar Speckle Displacement in weeks 45 thru 48 and two 4-hour supports each week in week 44 thru 46 for Mars ranging, MEX requires four 8-hour supports at DSS-14 for occultation/orbital science support and two 4-hour supports at DSS-63 for bi-static radio science activity.

M01O has 50-70% overlap with CAS, 10-20% overlap with Deep Space Station (DSS) Maintenance, 40-50% overlap with asteroid 1862, 100% overlap with MEX and 100% overlap with MGS.

During this period of high activity, contention can be reduced if M01O increase their MSPA support with Mars missions (MEX and MGS).

In January 2006 (each of weeks 02 and 03), CAS requires 1 to 4 passes for Saturn tour, DSS Maintenance requires 4 periods of preventative maintenance, 1 period for bearing maintenance and one period for antenna calibration on the 70-meter subnet, MEX requires three 10.8-hour supports at DSS-14,63 for orbital science/occultation, MEX/MGS require two 10-hour MSPA supports for MEX orbital science and MGS mapping respectively, MEX also requires two 4-hour supports for bi-static radio science at DSS-43, M01O/MGS require 4 to 5, 10-hour MSPA supports for mapping, MGS also requires two more 10-hour supports for mapping, Voyager 1 (VGR1) requires one 2.5-hour pass for routine uplink at DSS-14,43 and Voyager 2 (VGR2) requires 2 to 3 passes each 8-hour in duration for routine tracking and one 4.5-hour pass for routine uplink at DSS-43.

M01O has 30-60% overlap with CAS, 30-40% overlap with DSS Maintenance, 90 - 100% overlap with MEX/MGS, 20-30% overlap with VGR1 and 65-70% overlap with VGR2.

During this period of high activity, contention can be reduced if M01O increase their MSPA support with MEX and MGS.

In week 10 of 2006, DSS Maintenance requires 4 periods of preventative maintenance, 2 periods of bearing maintenance and one period for antenna calibration on the 70-meter subnet, GSSR requires 6 supports each 8-hours long for asteroid 2000 PN9 observation and three 2-hours supports for mercury /AO (Arecibo) ranging at DSS-14, MEX requires seven 8-hours passes for occultation and orbital science support, out of which 3 supports are already combined (MSPA) with M01O, Mars Reconnaissance Orbiter (MRO) requires three 8-12 hours supports for Mars Orbit Insertion, SOHO keyhole requires eight 4-hour supports and one 8-hour support for keyhole maneuver, VGR1 requires one 2.5-hour pass for routine uplink at DSS-14,43 and VGR2 requires one 7.4-hours support for DTR playback and one 2.5-hours support for routine uplink at DSS-43.

M01O has 50-70% overlap with DSS Maintenance at DSS-14, 63 and 20-30% overlap with DSS-43, 90 - 100% overlap with MEX/MGS/MRO, 100% overlap with asteroid PN9 at DSS-14, 50% overlap with SOHO, 10-20% overlap with VGR1, 40 -50% overlap with VGR2.

During this period of high activity, contention can be reduced if Mars missions (MEX and MGS) agree to increase MSPA support with M01O.

Figure 3 THEMIS Augmentation Dec 2007 - Apr 2008

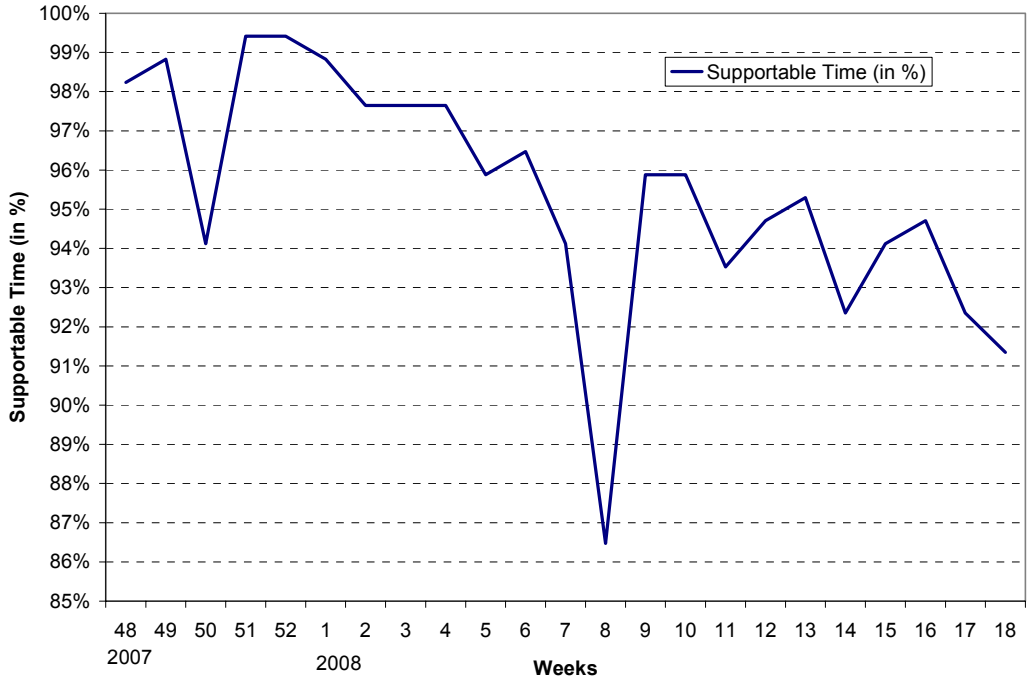


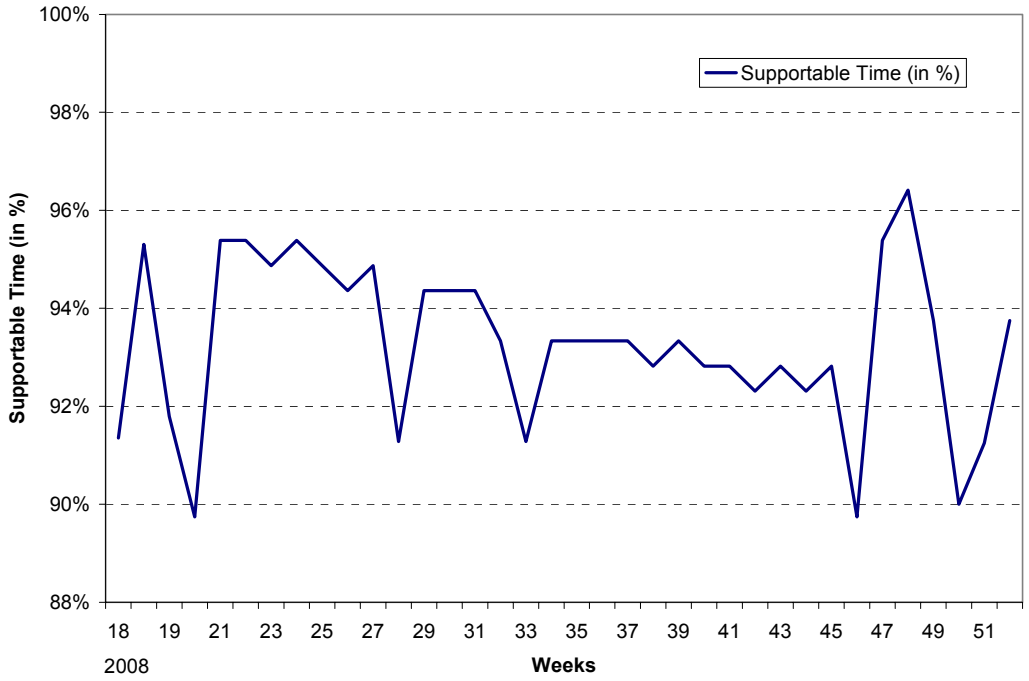
Figure 3 shows the weekly supportable percentage of requested time for the THEMIS augmentation period from December 2007 thru April 2008. During this period M01O requests for 20-hours per day on the 70-meter subnet and should expect to receive on an average 90 to 95% of the requested time except in week 08 of 2008 where the supportable percentage falls below 85%.

In week 08 of 2008, contention is mainly at DSS-14. DSS Maintenance requires 5 periods of preventative maintenance each ranging from 6 to 8 hours at DSS-14, DSS-43 and DSS-63 and one period of bearing maintenance at DSS-14, CAS requires 1 support of 9-hour duration for Saturn tour at DSS-14,63, EVN requires one 5-hour support for pre calibration and two 16-hour support at DSS-14 and DSS-63 simultaneously for the E500 J-M4 activity, GSSR requires 6 supports of 8-hour duration each for the asteroid 4450 Pan observation at DSS-14.

M01O has significant overlap with asteroid 4450 Pan and would require negotiations with supports at DSS-14. It has 40-70% overlap with CAS, 50% overlap with EVN support and 30-40% overlap with DSS maintenance at DSS-14, 63.

M01O can achieve increased supportability through negotiations with EVN to reduce its support and if GSSR can move its supports to observe asteroid 4450 Pan outside M01O view period.

Figure 4 Augmentation for PHX UHF Relay Support



Phoenix UHF Relay Support Augmentation

Figure 4 shows the weekly supportable percentage of requested time for Phoenix UHF Relay Support augmentation period from May 2008 thru November 2008.

During this period M01O requests for continuous coverage on the 70-meter/34m subnet and should expect to receive on an average 90 to 93% of the requested time.

MCD-3 Usage

MCD-3 is a unique piece of telemetry equipment. Analysis for MCD-3 usage was performed by comparing the usage patterns of the missions (stated below) based on their current view periods and the current equipment inventory. Currently there are 3 MCD-3s at Goldstone (GDS), 2 at Canberra (CAN), and 3 at Madrid (MAD). There will be a problem with MCD-3 usage only when more than three spacecrafts (including M01O) align significantly at GDS and MAD and more than two spacecrafts (including M01O) align significantly at CAN. The missions that currently use MCD-3 are CAS, DIF (Deep Impact Flyby), WMAP (Wilkinson Microwave Anisotropy Probe), SDU, STF (Spitzer Space Telescope), MGS and M01O.

WMAP requires MCD-3 on each track and only uses 70-meter antennas. It requires one 2.5 hours support per day including the setup time, which can be scheduled outside M01O view. Also during the study periods there is no significant overlap with M01O view; hence in general there is no MCD-3 conflict with WMAP.

M01O and MGS overlap 100% and if there are at least 2 MCD-3 available at each complex M01O should have no contention with MGS regarding MCD-3 usage in case of MSPA support.

January to June 2005
DIF, SDU and MGS are the missions that overlap significantly with M01O view in this period. M01O and MGS overlap 100%. In the months of January and February 2005, though DIF has 75-80% overlap with M01O view it does not require MCD-3. It uses MCD-3 only during the encounter and encounter rehearsal activity (May 23 to July 10, 2005) but the overlap with M01O view is not significant during this period. Hence we believe M01O should have no contention with DIF for MCD-3 in this period.

SDU overlaps from 65% in February to nearly 100% in June 2005. It uses MCD-3 only on the 70-meter antennas. During this period one 7.5-hours support is scheduled every 3 to 4 weeks. If SDU support is not scheduled at DSS-43 during the period when M01O and MGS have MSPA support at DSS-43, M01O should have no contention with SDU for MCD-3 usage.

February to December 2006
During this period CAS, STF and MGS have significant overlap with M01O view. STF requires two 2-hour passes per day including the set up time which can be accommodated outside M01O view. Hence in general there should be no contention with STF. M01O and MGS overlap 100%. M01O does not have MCD-3 contention with CAS at Canberra because CAS mostly uses GDS and MAD antennas. Since there are 3 MCD-3s available each at GDS and MAD, there should be no MCD-3 conflict with CAS during this period even when M01O and MGS are in MSPA support at GDS and MAD.

January to September 2007
There is no MCD-3 conflict during this period.

March to December 2008
During this period STF and CAS have significant overlap with M01O view. STF needs two 2-hour passes per day including the set up time which can be scheduled outside M01O view. Hence M01O in general should not have MCD-3 conflict with STF. M01O does not have MCD-3 contention with CAS at Canberra because CAS only uses GDS and MAD antennas. Since there are 3 MCD-3s available each at GDS and MAD, there should be no MCD-3 conflict with CAS during this period even when M01O and MGS are in MSPA support at GDS and MAD.

Conclusion
In conclusion we believe that Mars Odyssey can achieve nearly all of the requested support with minimal impact to other users for most of the extended mission. M01O should increase their MSPA support with MEX and MGS above their expressed guidelines and/or some negotiations with MEX and MGS to reduce their support or move their support to 34-meter may be needed to resolve contention in the periods detailed above. In general, M01O does not have MCD-3 conflict with other users except during

the period February to June 2005 at Canberra (DSS-43) which can be avoided with careful scheduling and negotiation with Stardust. Overall, Mars Odyssey should receive in excess of 85 to 90 % of the requested support and may successfully improve that amount with careful scheduling and the use of the MSPA capability during periods of high activity.

As always, the results of this study are preliminary in that network loading changes as requirements for planned missions are input and updated. We will continue to work with Mars Odyssey and other users of the DSN to maximize the time available for each individual user.

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19-May-04

User Loading Profiles

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M01O